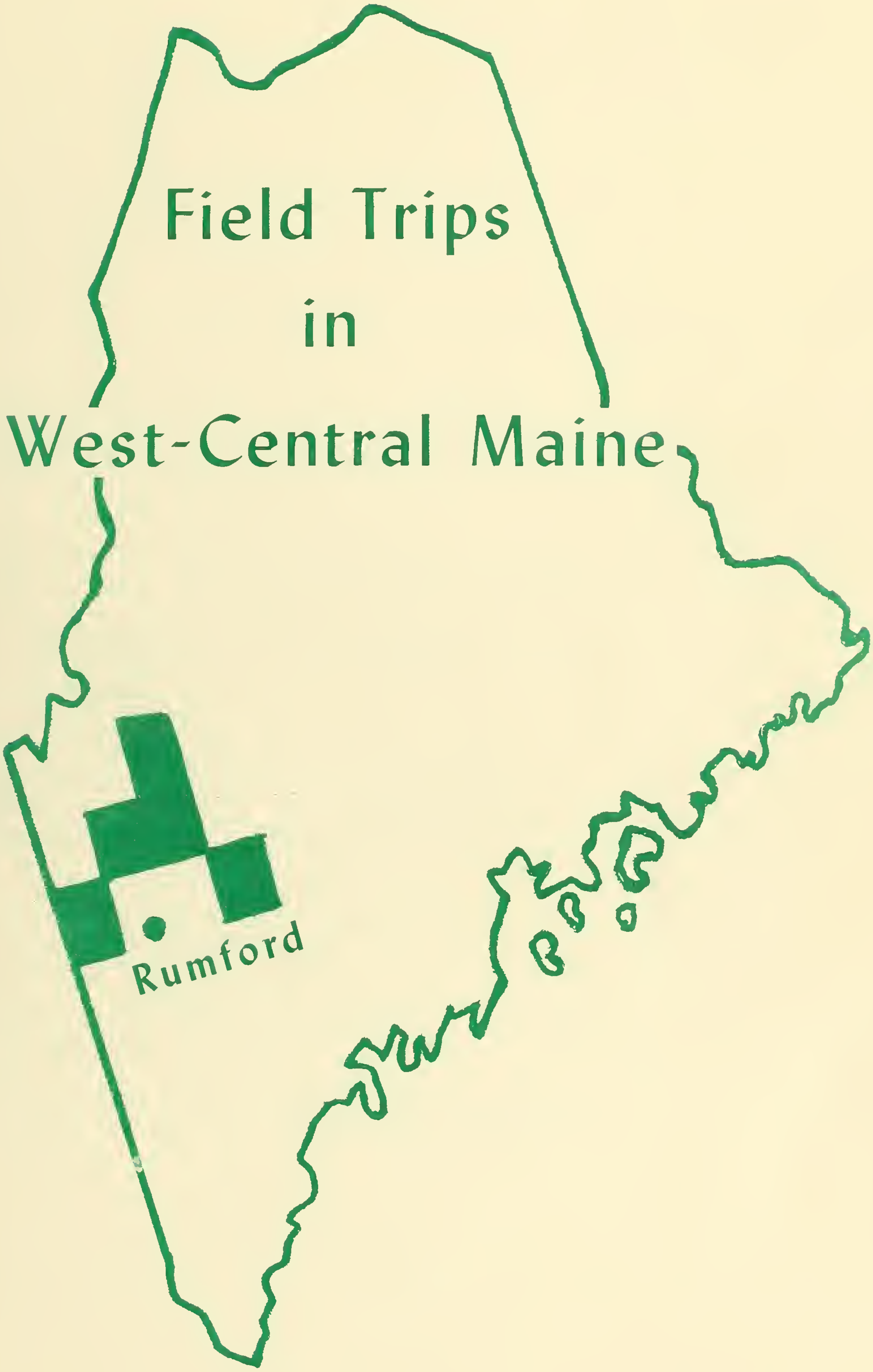
Field Trips in West-Central Maine



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GUIDEBOOK

for

THE FIFTY-SECOND ANNUAL MEETING

of the

NEW ENGLAND INTERCOLLEGIATE GEOLOGICAL CONFERENCE

FIELD TRIPS IN WEST-CENTRAL MAINE

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Editors

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FIELD TRIPS IN WEST-CENTRAL MAINE*

INTRODUCTION

By

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West-central Maine is underlain by metamorphosed and highly deformed Paleozoic sedimentary and volcanic rocks which are intruded by several Devonian plutons ranging in composition from granite to gabbro. Thick Pleistocene deposits cover much of the bedrock. Stratigraphic correlation of rock units is difficult as a result of: complex structure, sedimentary facies changes, metamorphic facies changes, and interruptions of continuity by the Devonian age plutons. The field trips which discuss these bedrock problems will traverse the following quadrangles in west-central Maine: Stratton (Trip A), Rangeley and Phillips (Trip B), and Old Speck Mountain (Trip D).

Structural interpretations are in some cases tentative where stratigraphic relationships are not completely worked out. Folding of all orders of magnitude is present and isoclinal folding is common. Wolfe (Trip B) considers faulting to be of major importance in the Rangeley and Phillips quadrangles.

In the area of trips A and B the metamorphosed sedimentary rocks range in metamorphic grade from chlorite to staurolite zone. Aureoles of higher grade metamorphism surround the Devonian plutons. In the area of Trip D the grade of regional metamorphism increases to the stillimanite zone. The plutons appear to be at least partly syntectonic in the high grade zones of regional metamorphism and are primarily post-tectonic in the low grade zones of regional metamorphism. The orogeny and metamorphism are primarily of Devonian age.

Trip A (Griscom) traverses the northern portion of the area in the Stratton quadrangle and demonstrates a sequence of rock units which can be correlated in a general way with the lower Paleozoic stratigraphy of the Moosehead Lake area (Boucot, Griscom, Allingham, and Dempsey, 1960). Trip D (Milton) traverses the Old Speck Mountain quadrangle. Milton informally extends the New Hampshire stratigraphy (Billings, 1956) northeastward from the fossil-dated rocks in the general locality of Littleton and Mt. Moosilauke. This approach involves a correlation over a distance of fifty miles along which intrusive rocks and structural complication preclude direct tracing of rock units. Trip B (Wolfe) traverses an area in between trips A and D. Here a tentative stratigraphic sequence has been established which as yet cannot be clearly related to either the New Hampshire or the Moosehead Lake sequences.

Pegmatite dikes cut the metamorphic and igneous rocks, being especially abundant in the Rumford area. Trip E.(Peacor)will visit the pegmatites

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The late Pleistocene and Recent events in west-central Maine are investigated in the Farmington area on trip C (Caldwell). This trip includes a visit to a pre-Wisconsin Pleistocene till which is believed to be unique in New England .

In both central New Hampshire and the Mooshead Lake area the lower Paleozoic stratigraphic column may be generalized as follows: a diverse assemblage of pre-Silurian sedimentary and volcanic rocks, calcareous sedimentary rocks being scarse; fossiliferous Silurian limey rocks and sandstone with occasional conglomerates, often resting inconformably upon the older rocks; dark gray slates and sandstones of Early Devonian age sometimes with interbedded volcanic rocks but rarely containing limey rocks. The rock units in the Stratton quadrangle (Trip A) fit into the above sequence. Possible correlations of certain rocks in the Rangeley and Phillips quadrangles (Trip B) with the generalized sequence are: arenaceous and calcareous rocks seen near Madrid, Maine, with the Silurian limey rocks; gray siltstones and sandstones seen near Dyer Hill, Maine with the Early Devonian gray slates. The lack of volcanic rocks in the area of trip B may indicate that an incomplete section of pre-Silurian rocks is exposed, because there is a considerable thickness of pre-Silurian volcanic rocks to the north (Trip A and southwest (Trip D). The Silurian calcareous units are apparently absent in the area of Trip D, but the various metamorphosed sedimentary and volcanic formations can be provisionally assigned an Ordovician to Devonian age. It is presently impossible to correlate clearly with each other all the rock units in the areas traversed by Trips A, B, and D but a few possibilities have been suggested above.

REFERENCES

Billings, M. P., 1956, The Geology of New Hampshire, Part II - Bedrock Geology: Concord, N. H., New Hampshire State Planning and Development Commission, 203 p.

Boucot, A. J., Griscom, Andrew Allingham, J. W., and Dempsey, W. J., 1960 Geologic and Aeromagnetic Map of Northern Maine: U. S. Geol. Survey open-file report.

TRIP A GEOLOGY OF THE STRATTON QUADRANGLE, MAINE*

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GEOLOGY

The layered rocks of the Stratton quadrangle consist of a thick sequence of metamorphosed lower Paleozoic shales, sandstones, and calcareous sedimentary rocks together with several thousand feet of basaltic volcanic rocks. Large plutons of granite, diorite, and norite intrude and metamorphose the layred rocks.

The pre-Silurian rocks are restricted to the northwest corner of the quadrangle, near Eustis, and are isolated from younger metamorphic rocks by a large granite intrusion. In this area a conformable succession of three units (table 1)will be examined (stops 2, 3, and 4).

Table 1

Pre-Silurian Stratigraphy

Basaltic volcanic rocks, including flows, tuffs, and breccias
Greenish-gray slate, some purple slate, and scarce thin sandstone beds.

Massive sandstone, with interbedded gray slate and scarce quartz pebble conglomerate. Upper portion contains beds of felsic tuff up to three feet thick.

The basalt lies unconformably below Silurian rocks at Jim Pond in the Spencer quadrangle where the southwest end of the Moose River syclinorium is exposed.

Rocks of Silurian and Devonian(?) age underlie the remainder of the Stratton quadrangle. A thin-bedded unit of Silurian (?) age is characterized by layers of calcsilicate minerals and crops out in an anticlinal structure on the south side of Bigelow Mountain (stops 5 and 7). A similar cal-silicate hornfels at Limestone Hill in the northeast corner of the quadrangle contains Silurian fossils. Above these rocks is a thick sequence of gray slates which contain abundant sandstone beds and which often show cyclical bedding (stop 9). The slates are tentatively correlated with the Early Devonian gray slates of the Littleton formation in New Hampshire and those of the Moose River synclinorium in Maine.

A large well-differentiated pluton consisting mostly of norite is present in the southeast portion of the Stratton quadrangle. We shall examine the norite near its upper contact (stop 6) and examine the more mafic layered rocks of the lower part (stop 8). A granite (stop 1) underlies the basin of Flagstaff Lake and is the youngest rock in the quadrangle.

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The granite is rimmed by an older diorite intrusive. The diorite also underlies the valley of the South Branch of Dead River. The diorite may be essentially the same age as the norite.

Trip A. Road Log
Leader: Andrew Griscom

Quadrangle maps needed: Rangeley, Kemmebago Lake, Stratton, Little Bigelow Mountain, Kingfield. The stops are in the Stratton and Little Bigelow Mountain quadrangles.

Assembly point: In Rangeley at the junction of Routes 4 and 16. Park on Route 16 headed north.

Time: Meet at 8:45 A.M., Saturday, October 8. This road junction is 43 miles from Rumford.

Mileage

0.0 Junction of Routes 4 and 16. Proceed north on Route 16.

3.7 Dynamited boulders of garnet-bearing gabbro and diorite are abundant along the road for the next five miles. Many bolders contain inclusions of massive bluish-gray cordierite. These hybrid rocks occur near the contacts of the large diorite and gabbro intrusive which underlies the valley of the South Branch of Dead River.

4.8 Bridge across South Branch of Dead River. Road ascends onto an esker and follows it for the next mile. View of Saddleback Mountain to southeast.

16.9 Bridge across Nash Stream. Outcrops of hornblends diorite and porphyritic granite which intrudes the diorite.

17.5 Stop 1: Dynamited bolder of porphyritic granite on north side of road. Note oriented phenocrysts and biotitic schlieren. The porphyroblasts (?) within the schlieren are similarly oriented. Elsewhere good outcrops of the granite show all gradations between angular diorite inclusions and biotite-rich schlieren.

18.6 Outcrops of granite

19.3 Stratton. Junction of Routes 16 and 27. Turn left and head north on Route 27. The next three miles of road after crossing the bridge over the Dead River is on an outwash plain.

23.0 Road junction at the Cathedral Pines. Benedict Arnold and his men passed through here on their march up the wilderness of the Dead River to attack Quebec. Turn left on paved road to Eustis Ridge.

23.7 Road crosses contact of diorite with the sedimentary and volcanic rocks of Eustis Ridge. Contact is thought to lie at the bottom of the hill. The lack of metamorphism higher than chlorite zone in the sedimentary rocks near the contact suggests that it may be a fault.

23.9 Outcrop of diabase dikes intruding slates.

24.4 Turn right onto dirt road

25.0 Stop 2: Park at sharp left turn in road. Climb through field to knob three hundred feet east of corner. This knob is at the nose of a very steeply plunging fold cut by diabase dikes which are not folded. The dikes may be offshoots from the diorite pluton. The layered rocks are massive beds of felsic tuff with interbedded gray slates and sandstones. Continue to another knob three hundred feet to the northeast. The view is one of the finest in Maine, a 360-degree panorama of mountains. The rock is a gray slatey tuffaceous siltstone stained brown by the weathering of pyrite. The beds are sheared and folded. Two hundred yards to the north on the north side of the cleared field are outcrops of sandy siltstones and gray slates. To the north the slates predominate over the coarser beds and this sandy, volcanic sequence grades upward into the green slates seen near Eustis. Return to Cathedral Pines.

27.0 Road junction at Cathedral Pines. Turn left (north) on Route 27.

27.9 From here to Eustis the road lies on one of the large eskers so common in Maine river valleys.

28.9 Kettlehold on west side of road.

29.3 Eustis. Outcrops of greenish-gray slate.

29.7 Stop 3: Outcrop of greenish-gray slates. Steeply plunging intersections of bedding and cleavage. This unit underlies the rocks of stop 2.

29.8 Road crosses Tim Brook and ascends on to outwash plain.

31.2 Stop 4: Outcrops of basaltic volcanic rocks. Mineral assemblage is chlorite-epidote-actinolite-albite. There are veins of epidote, calcite and asbestos. Return to Strattton.

43.1 Stratton. Junction of Routes 16 and 27. Turn left (east) on combined Routes 27 and 16.

44.1 Road ascends esker and is on or beside it for three miles. This esker shows clearly on the topographic map and is over seven miles long.

47.7 Stop 5: Bridge across Stoney Brook. Park in clearing on south side of road. Walk south about one hundred yards on dirt road following west bank of brook. First outcrop is beneath a fifteen foot erratic boulder in the brook. This is a typical example of the calc-silicate unit in an area where the siltstone and subgraywacke have been converted to a gneiss and the bedding destroyed, leaving a swirled foliation. Bedded fragments of the calc-silicate layers were more resistant to this process and are preserved in random attitudes, having the appearance of inclusions.

An amphibolite crops out at the first sharp bend in the stream. Near the cross-cutting granitic pegmatite dikes the hornblende is transformed into biotite. The amphibolite is probably a metamorphosed mafic dike.

47.8 A good view of Bigelow Mountain to the north. The crest of this range is a stillimanite-cordierite hornfels along the south side of the granite intrusive which underlies Flagstaff Lake.

50.9 Bigelow. To the south is the Sugarloaf Mountain ski area on Maine's second highest mountain (4237'). All the mountains in view are composed of norite, the contact of which passes through Bigelow. The skyline peaks are underlain by the more mafic layered rocks in the lower part of the intrusion. For the next nine miles the road lies within the norite and parallels the contact which is on the slopes half a mile to the north.

54.5 Stop 6: Public camp site at bridge crossing stream. Start fifty feet below stream junction and walk south bank of Carrabassett River. Norite contains biotite and hornblende because of proximity to upper contact. At stream junction cross the contact of a muscovite-biotite granite dike. Granite continues for three hundred feet, followed by fifty feet of biotitic norite. The norite then grades rapidly into a biotite diorite which locally contains up to seventy percent garnet. Occasional cordierite inclusions occur. The diorite is a hybrid rock formed at the contact between norite and a sillimanite-cordierite hornfels. More typical norite crops out fifty feet upstream from the diorite.

57.2 Carrabassett. Turn left (north) on dirt road.

57.5 Turn left on dirt road just before passing red barn. As many cars as possible will be left here because it will be difficult for a procession of cars to turn around on the road.

61.0 Stop 7: Town line. Gate on bridge crossing a brook. Park so that cars can pass. Descend stream which contains numerous outcrops of well-bedded calc-silicate unit. Cross a hundred foot wide amphibolite dike with chilled contacts. Small whitish spots in the aluminous beds are andalusite. An anticline one hundred feet beyond the dike has a coarsely rodded appearance at the crest because of incipient boudinage. Below here the stream descends a spectacular series of falls in a gorge cut in an amphibolite intrustion. Granite pegmatite and aplite dikes cut across the amphibolite. The easiest route down is along the east bank. Return to Carrabassett.

64.8 Carrabassett. Turn left (southeast on Routes 27 and 16.

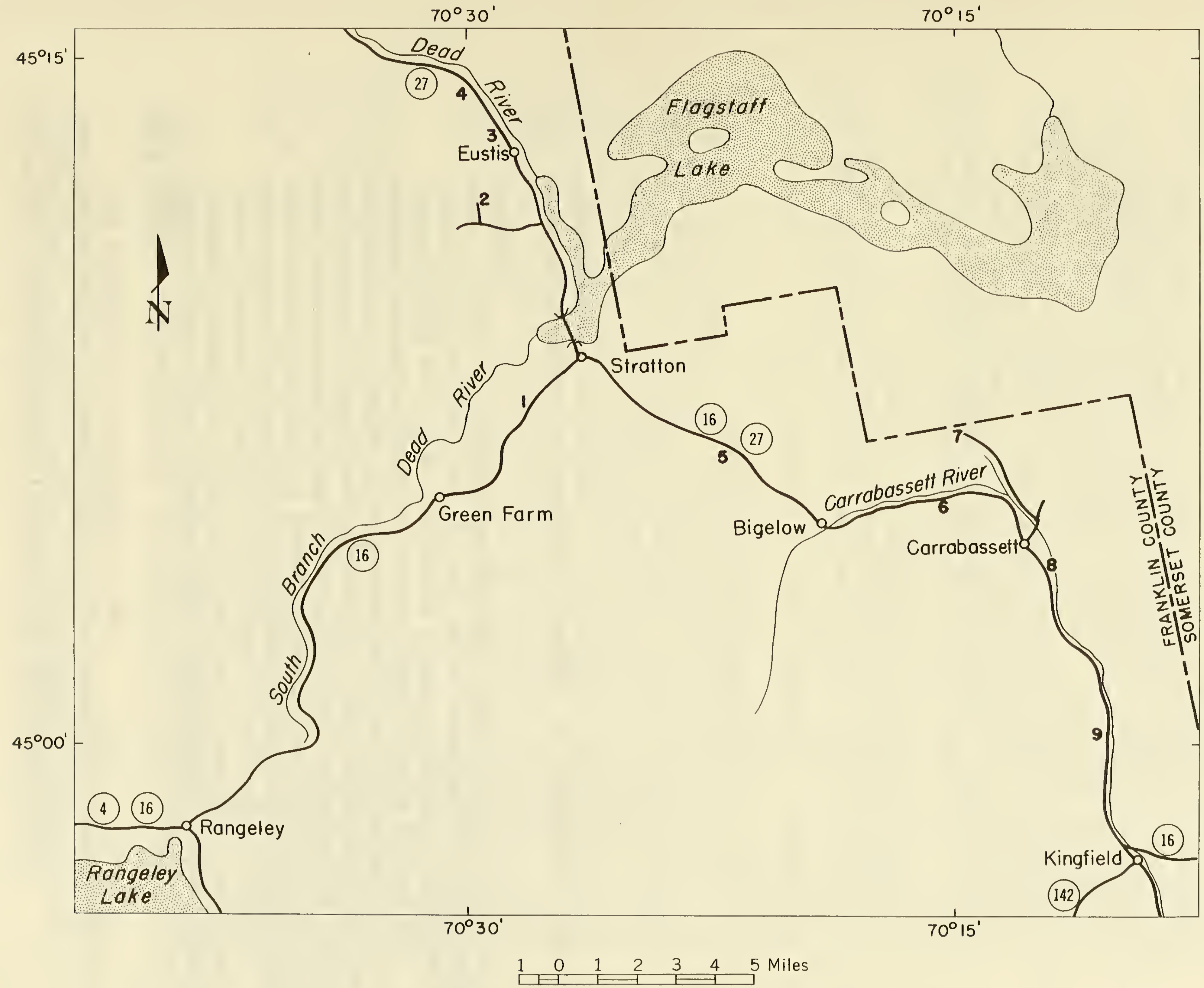
65.9 Stop 8: Spring Farm. Norite outcrops in the river under the bridge show compositional layering, including thin layers of anorthosite. Some layers contain poikilitic hypersthene crystals up to two inches long. Note the alteration to green chlorite-actinolite-albite assemblages adjacent to thin veins.

67.4 Road crosses contact of norite with gray slate unit.

69.2 Large outcrop of andalusite hornfels which is former gray slates and sandstones of Deronian (?) age.

70.8 Stop 9: Faulted fold in cyclicly layered andalusite schist on west side of road. Note: graded beds, crossbedding, false crossbedding caused by shearing along beds, incipient boudinage, consistent steep lineation parallel to fold axis, axial plane cleavage. The andalusite is in reality pseudomorphs of muscovite after chiastolite, and the chlorite is pseudomorphic after biotite. The original andalusite-biotite hornfels was the result of contact metamorphism of Deronian (?) slates by the norite. The later retrograde metamorphism to a muscovite-chlorite assemblage is caused by a younger granite intrusion which is exposed several miles to the east. The quartz veins are often restricted to the quartz-rich beds and are rimmed by concentrations of very large pseudomorphs after chiastolite. Rims of tourmaline and chlorite (after biotite?) are sometimes present.

74.4 Kingfield. Return to Rumford, a distance of 54 miles by way of Farmington.



ROAD MAP FOR TRIP A

Note: Numbers indicate stops

TRIP B

STRATIGRAPHY AND GENERAL GEOLOGY

Rangeley to Phillips, Maine

C. W. Wolfe, Boston University

The stratigraphic sequence in the Rangeley and Phillips Quadrangles and in the quadrangles to the east has not been completely determined as yet. In order that a basis for discussion be available, the following tentative stratigraphic column is suggested.

Rocks comparable to those on Dyer Hill, Kingfield Quadrangle (Probably the same as the Monson slate)

Gray siltstones and sandstones. Siltstones occur with thick sections practically devoid of bedding. Interbedded siltstones and fine gray sandstones in lower part of formation. Siltstones develop excellent slatery cleavage which with secondary jointing produce rhomboid small cleavage fragments. Observed in the Kingfield, Anson, Farmington, Kingsbury, and Bingham Quadrangles. Type locality on Dyer Hill in the Kingfield Quadrangle. Best exposed in the Bingham and Kingsbury Quadrangles. Excellent andalusite and chiastolite recrystallites develop under metamorphism.

* * * * * *

Rocks comparable to those at Madrid, Phillips Quadrangle (Mid-Niagaran, equivalent of Fitch formation in New Hampshire)

The lower basal section of the Madrid Formation is comprised of massive gray to violetish arenaceous rocks. The beds are two to four feet thick and often contain elliptical highly calcareous zones which are interpreted as syngenetic calcareous concretions. Higher in the Madrid section are some sulfide horizons and black shales; but most notable are several horizons of ribbon limestone with an average thickness of about 200 feet. These horizons are particularly subject to intense deformation along longitudinal faults, developing shear folds of one inch to one foot amplitude. Plunges of these folds and attutudes are extremely variable. Metamorphism produces common suites of lime silicate minerals.

* * * * * *

Rocks comparable to those at Smalls Falls, Rangeley Quadrangle

This formation is extremely variable in commosition and in thickness. It was deposited in an anaerobic closed-basin environment where considerable quantities of liberated H_2S combined with iron to form iron sulfide, both pyrrhotite and pyrite. The rock types are quartzites, argillites, and limestones. All of them are black in color. There are pseudo-

Rocks comparable to those at Smalls Falls, Rangeley Quadrangle (Cont.)

morphic voids in the argillites which have undergone minor to middle grade metamorphism. Some quartzites contain more than 15% by volume of sulfide. Deformation in the formation is very extensive. Folds with amplitudes of 100 feet and more have been plane tabled. They always pinch out along longitudinal faults which are usually silicified and sometimes sulfide.

* * * * * *

Rocks, comparable to those on Perry Mt., Rangeley Quadrangle. (Perhaps equivalent of Clough quartzite in New Hampshire)

The formation is typically arenaceous, impure, well-bedded, noncalcareous, usually nonsulfidic. The basal section contains quartz conglomerate locally in the Rangely Quadrangle. Most of the formation is highly impure but well bedded. Whiteweathering, arkosic, thick-bedded quartzites occur in the upper 2,000 feet of the formation. The upper 200 feet are cyclically bedded with well-defined graded bedding. Type locality is in the Perry Mt. region of the Rangeley Quandrangle. Metamorphism of the cyclically bedded material produces excellent staurolite schists. The lower segments of the formation alter to a sandy biotite recrystallite. The Perry Mt. type rocks are probably directly overlain by the Madrid type rocks in the southwestern part of the Rangeley Quadrangle.

* * * * * *

Rocks comparable to those along Lost Brook, Cupsuptic. Quadrangle

The type locality is along the Lost Brook in the Cupsuptic Quadrangle. Typically homogeneous argillaceous rock with well-developed cleavage. A secondary healed cleavage is often observed approximately perpendicular to the open cleavage. Bedding is inconspicuous or absent in the type locality, but red and green bedded slates are observed on the falls of the Kennebago River in the Cupsuptic Quadrangle and extend through the Kennebago Lake Quadrangle. Rock is readily converted into a hornfels or staurolite recrystallite. The famous Rangeley Conglomerate which outcrops east of Rangeley is visualized as a local lensy phenomenon near the top of the Lost Brook type rocks. This quality will be observed on the side trip up Cascade Brook just east of the outstanding road-cut exposure of the conglomerate member. It is believed that the Lost Brook and succeeding mud deposits interfingered with the more clastic and calcareous horizons in a sinking basin. Following Lost Brook deposition, mud continued to be deposited off shore while the clastic sediments were being deposited near shore with an interfingering relationship with the off-shore deposits. Mud was finally laid down upon the

Rocks comparable to those along Lost Brook, Cupsuptic Quadrangle. (Cont.)	clastic sediments producing the Dyer Hill type rocks. This climbing of the column could presumably extend from Upper Ordovician (Albee) time to Devonian (Littleton) time, although there is no real evidence for this.

PHANERITIC ROCKS

Volcanics are exceedingly scarce in most of the area mapped. Basaltic dikes are, likewise, extremely rare. Gabbro, dunites, and diorites occur in the Moxie Mt. region of the Bingham Quadrangle. These are visualized by the author as metamorphosed flows and possibly metasediments of the proper initial bulk composition. The source fissure for the Moxie complex has been identified aeromagnetically to the north. One two-foot peridotite dike has been observed to the south.

Strong evidence is at hand to suggest that some of the granites represent gradual recrystallization of hornfels without passing through a magmatic phase. Large porphyroblasts of feldspar have been observed in isolated positions in the Little Bigelow Mt. hornfels and in other areas. Sill-like masses of porphyritic granite at the southerly border of the Saddleback Mt. phaneritic mass are believed to be the result of preferential transformation along certain horizons in the Perry Mt. type rocks. It seems likely that many of the granite bodies, particularly in their core regions, were truly magmatic since randomly oriented blocks of Perry Mt. rocks can be observed in the Saddleback granite in some areas.

Compositions and textures of the phanerites are extremely variable. Leucocratic to melanocratic granites, granodiorites, and quartz monzonites are the common types. Pegmatitic and aplitic masses are usually dike-like in form and appear to have developed by later solutional activity along major zones of weakness. Large pegmatite bodies are rare to absent.

METAMORPHISM

Aside from the frequently observed so-called contact metamorphism around the phaneritic bodies, most of the rocks in the region have not undergone intense metamorphism. Very low-grade (sub-chlorite) to low middle-grade (staurolite) metamorphic effects have been observed. In the transformed region of the southern part of the Farmington Quadrangle, Sillimanite does occur. The phanerites of the region were probably partially the result of in situ transformation and partially magmatic, but the regional P-T conditions were probably appropriate for sillimanite crystallization.

STRUCTURE

The characteristic structural pattern is that of vertical to nearly vertical rocks for tens of miles across the regional strike which is roughly N 35 E. Near certain granite bodies, the strike may shift notably; and occasionally dips as low as 25 degrees are noted in these regions. A striking structural feature of the rocks is the presence of longitudinal faults. They approximate the attitude of the bedding, but frequently cut it both in strike and dip at slightly divergent angles. Cleavage in these areas parallels the faults, but elsewhere it is parallel to the bedding. Quartz is typically found in pods and veins along the fault planes where the rocks are devoid of calcareous matter. Where carbonates are present in the bordering rocks, calcite or ferroan calcite, or some ferroan containing carbonates, is found together with the quartz in the pressure shadows of the fault zones. Shear folds of variable magnitude and attitude are found in the fault zones. Transverse faults trend roughly N 45-55 W and seem to be somewhat later than the longitudinal faults. The transverse faults are rarely mineralized. It is believed that the rocks achieved their present attitude before induration took place. The faulting, also, probably preceeded induration of the rocks.

GEOMORPHOLOGY

The major stream patterns, except for the modifications induced by glaciation, are controlled by the longitudinal faults or soft rock zones, and by the transverse fault zones. A regional southerly slope for the area has produced a few major stream courses directly to the south. Some of these may flow in north-south fault zones induced by the Triassic movements.

Most of the higher peaks in the area are upheld by extremely resistant hornfels or by a porphyritic granite phase which is the roof-rock type for many of the granite bodies. Once the hornfels and roof phase of the cupola-like granite bodies is breached, weathering and erosion of the interior granite proceeds very rapidly, and basins which are surrounded by hornfels and underlain by granite are extremely common.

Glaciation has completely disarranged the drainage, producing many beautiful falls and cascades in the area. The falls on Mountain Brook in the Rangeley Quadrangle rise vertically for 100 feet, and a rock-floored set of cascades rises above these falls for a vertical distance of 400 feet in a very short distance. Many of the falls occur where the present drainage descends sharply from one erosion surface to another. This is particularly true of Mountain Brook Falls.

Glacial striae generally trend S 25 E to S 35 E, but in the vicinity of large mountain masses, such as Saddleback or Abraham, the trend of the striations may swing to S 65 E. Erratics are extremely common and can be readily traced to their sources in many cases. Erratics weighing hundreds of tons are common. One transported bolder southeast of Phillips has traveled 15 miles and still weighs over 1,000 tons. A porphyritic granite erratic weighing more than 8,500 tons has traveled 8 to 9 miles. Extreme plucking may be noted on the leeward side of many mountains and hills. The walls of valleys which trend in a southeasterly direction are often highly oversteepened. The best example is Tumbledown Mt. on the Weld-Byron road, Rumford Quadrangle.

Distinct erosion surfaces are noted at 1,100', 1,400', 1,700', 2,100-2,300', 2,700', and less distinctly at higher levels. These are believed to have resulted from a stepped uplift with concomitant sudden lowering of regional base level.

Every major stream is characterized by two or more constructional terraces. Some are entirely coarse clastics; others are partially or completely underlain by clay, either marine or lacustrine.

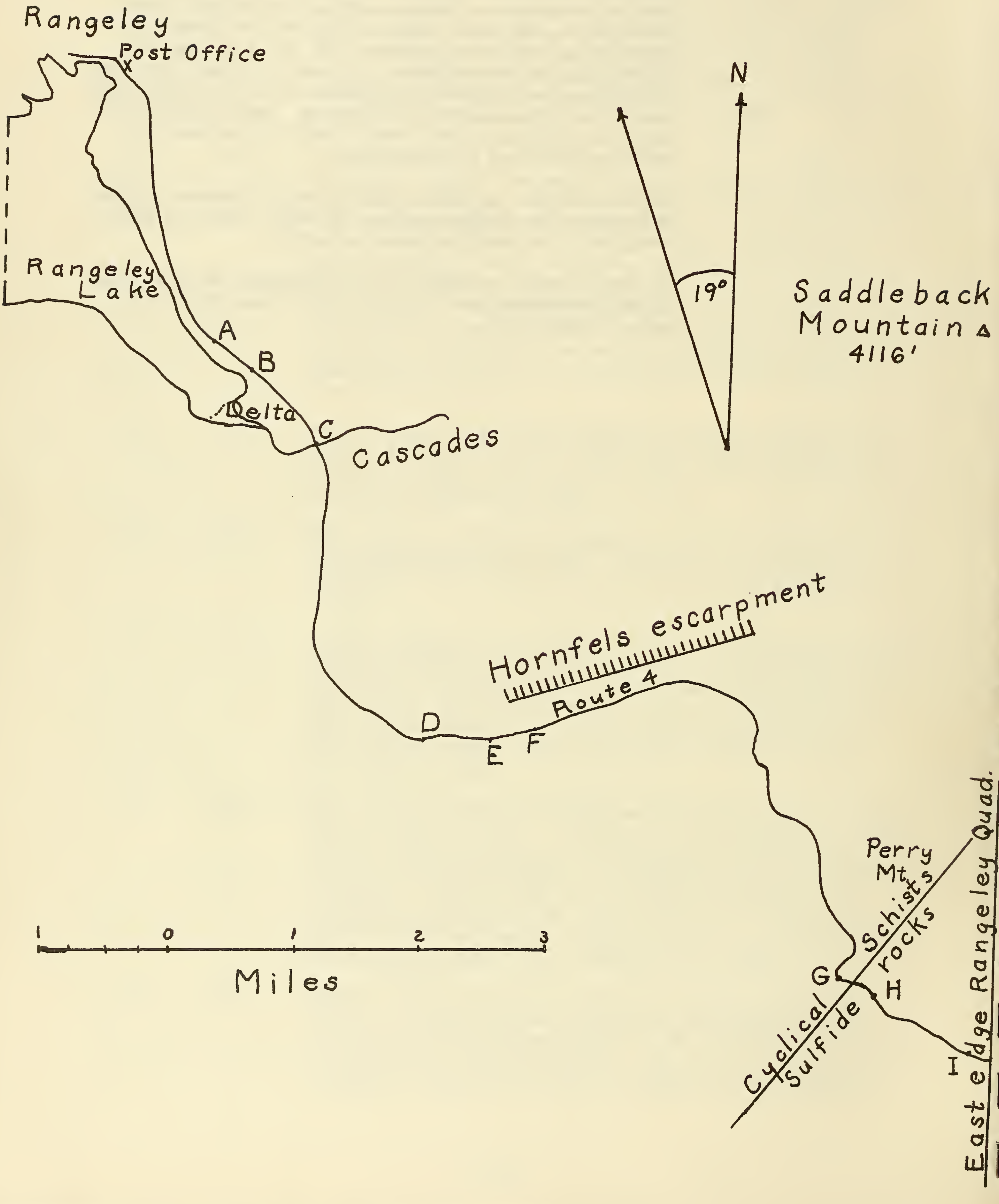
Trip B Road Log--RANGELEY TO PHILLIPS STRATIGRAPHY TRIP

Map Location	Miles	
	0.0	Trip begins at Playhouse Theatre, Rangeley, going east.
A	2.1	Upper Lost Brook or Lower Perry Mountain type siltstones, shear folds are common. Excellent glacial striae and polishing. Lake to right reaches depth of 145 feet in this area, although most of lake approximates 35 to 50 feet. Deepest area may represent erosion along transverse fault.
B	2.5	Outstanding exposure of Rangeley conglomerate which is here visualized as lying at the approximate top of the Lost Brook type rocks and at the base of the Perry Mt. type. Characterized by heterogeneous quality of pebbles, elongated pebbles, and opalescent quartz grains. Interbedded with coarse to medium-grained gray arenaceous rocks with beds up to five feet thick. Poor graded bedding seems to indicate up to east. Sheeting is notable.
C	3.3	Cascade Brook. We shall walk up this brook 1/8 mile to see lenses of conglomerate in siltstone, pseudomorphs after staurolite, pseudo ripple marks, and cascades. Stream shows obvious superimposed character. The eastern end of Rangeley Lake at this juncture is being filled with sediments from the Cascade Brook and from Long Pond Brook. Extensive delta can be seen at this stop.
D	6.15	An exception to the rule that the rocks in the area are nearly vertical. Rocks contain some sulfide which weathers to produce purplish-brown limonite stain on rocks. Rocks are interbedded calcareous quartzites, lime silicate beds, and siltstones. The one-mile section of this rock which has just been traversed, ends abruptly to the north. It is here interpreted to be a lensy deposit in the Perry Mt. type of rocks. Evidence is not good. Long Pond to the right is visualized as a continuation of the traverse fault valley which continues to the east, forming outstanding cliffs and talus slopes.
E	6.6	Outcrop to right is comprised of fairly well-bedded, poorly assorted rocks of the "cruddite" phase of the Perry Mt. type of rocks. Attitudes of rocks are atypical for the area. Pseudomorphs after staurolite are abundant. Late stage retrograde metamorphism may be seen in some transversely oriented chlorite flakes.
F	7.0	Excellent picture of erosion surface at the general level of 1,700' a.s.l. Excellent view of hornfels excarpment down the road to the left. Hornfels has developed in the Perry Mt. type of rocks, particularly in the pelitic layers. Sandy layers form quartzite.

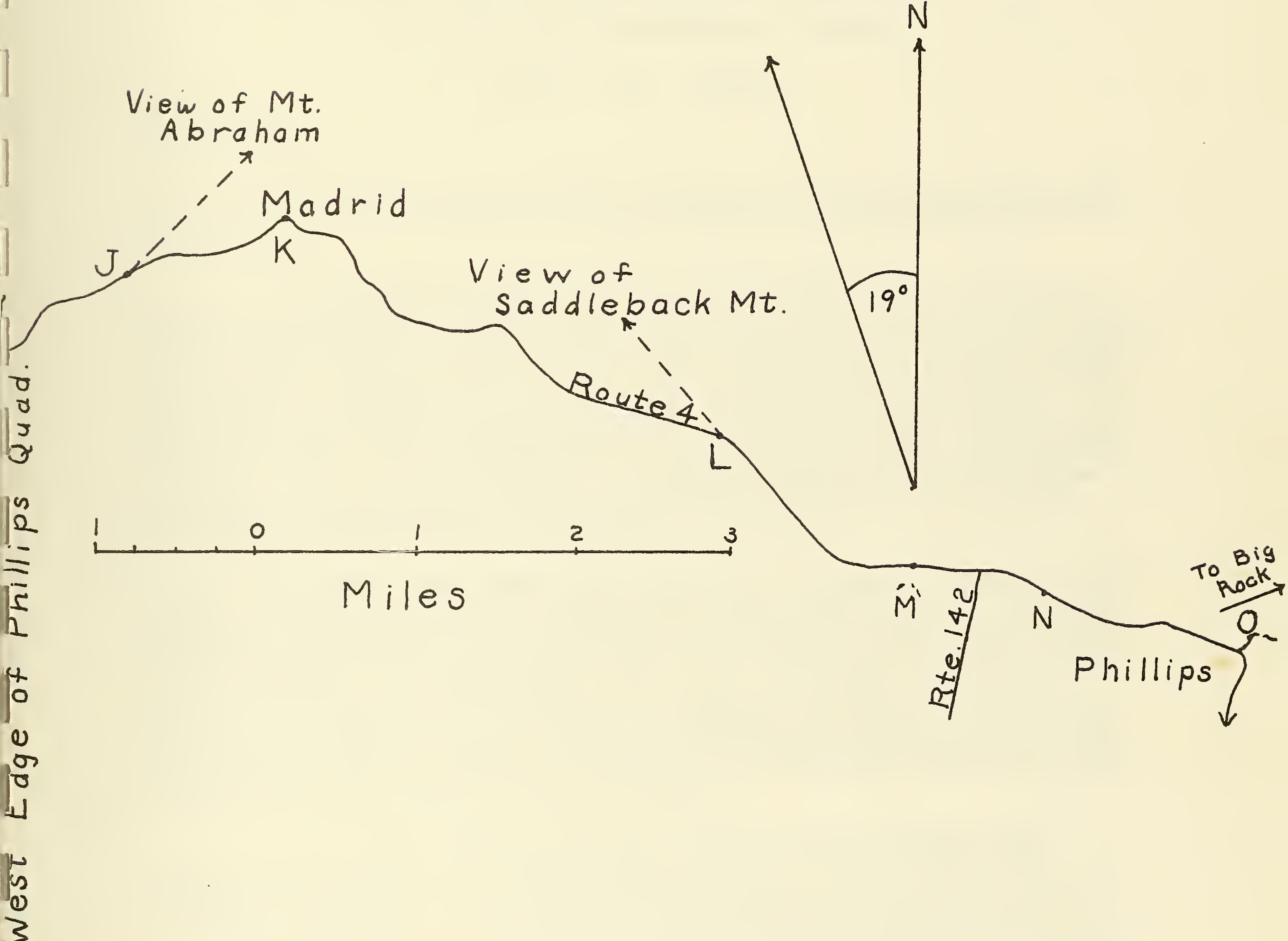
G	11.3 plus	Excellent exposure at hairpin turn of Perry Mt. type of rocks up the road and Smalls Falls type of rocks down the road. Contact here is within 100 feet. Contact strikes N 38 E and is continuous for at least 15 miles. Top of Perry Mt. type of rocks at this place is characterized by cyclical graded bedding. Graded bedding texture is inverted through metamorphism. Chlorite porphyroblasts which are transverse to the foliation are common. Most staurolites have been replaced.
H	11.9	Typical exposure of the Smalls Falls type of rocks. Lithology varies from pseudomorphic chiastolite phyllites to hard quartzites. Oriented pyrrhotite blebs are very common in the quartzites. The falls in the Sandy River at this point are very striking. Clean outcrops show much faulting of the transverse variety. These falls are at the 1,100 foot level. Comparable, falls, if not lovelier, are to be seen on the Chandler Mill Stream just over the divide, a good example of retreating falls past stream junctions resulting in two sets of retreating falls. A second set of falls is to be observed on both streams at the 1,400-foot level.
I	12.6	Harvey Pond. Note high plucked cliffs above Harvey Pond due to glacial activity. Excellent erosion surface is exposed on Smalls Falls type of rocks to the rear of the cliffs for almost one mile.
J	13.8	Excellent view of Mount Abraham, a resistant hornfels and interbedded quartzite ridge, produced by contact metamorphism of the Perry Mt. and the Lost Brook types of rocks
K	14.9	Typical exposure of the Madrid type of rocks in the Sandy River behind the town stores. Violetish quartzites, pseudomorphic staurolite schists, and thin-bedded lime silicate rocks. Concretionary lime silicate nodules are notable in the quartzites. Large masses of graphite have been removed from a pegmatite to the south of the town in the hill nearby.
L	18.1	Stop and look back at Saddleback Mountain, Maine's fourth highest peak at 4,116'. Southern end of mountain is hornfels and intercalated sill-like masses of porphyritic granite. Top of mountain is porphyritic granite. Saddle is granite, but the horn to the north is hornfels and quartzite of the Perry Mt. type of rocks. Large basin region to the southeast of Saddleback is in granite, with the hornfels ridge of Mt. Abraham to the north.
M	19.7	Obscure road into woods at height of land to the right leads to a rather unique lacustrine diatomaceous earth deposit in a quaking bog type of area. Material available for inspection and distribution. It is 0.3 mile to the junction of Routes 142 and 4 to check out your odometer.

N	20.4	From this vantage point, one of the typical lithologic controls on topography can be noted. The basin in the foreground, wherein lies the town of Phillips, is underlain by equigranular granite. The marginal hills and mountains to the west, south, and north are upheld by hornfels in various formations. Mt. Blue appears on the skyline to the southwest. We shall go into the town of Phillips and stand on the bridge above the Sandy River
O	21.8	to see the typical granite exposures. Turn left at 21.8 miles at the sign of the Rexall Drugs in the town of Phillips; 150 feet to the bridge.
		If time permits, we shall visit a huge 8,500-ton erratic of porphyritic granite nearby. It will require a moderate climb on a road for about 1/2 mile.
		If time permits, we shall go on to Strong, the next town toward Farmington, and visit the type locality of the rocks of Dyer Hill.

Rangeley-Phillips Road Log-I



Rangeley-Phillips Road Log II



TRIP C

THE SURFICIAL GEOLOGY OF THE SANDY RIVER VALLEY

FROM FARMINGTON TO NORRIDGEWOCK, MAINE

Leader: D. W. Caldwell

INTRODUCTION

Pleistocene age sediments exposed in the Sandy River valley offer a varied and interesting picture of late-glacial and post-glacial events in Central Maine.

Following the melting of the last continental ice in the area, a portion of the valley upstream was occupied by a glacial lake and the lower valley was submerged briefly by the ocean. Clays deposited in this lake and in the ocean are the sediments with which this field trip will be principally concerned. Exposures have been chosen to illustrate the relation of the clay deposits to both the stratigraphically older and younger sediments in the Sandy River valley. Evidence by which marine clay may be distinguished from lake clay will be considered. although no agreement on this subject is expected. One exposure contains well preserved marine molluscan fossils from which specimens may be collected.

A buried soil, tentatively dated as pre-Wisconsin in age on the basis of radiocarbon dating of fossil wood and a preliminary pollen study, underlies the youngest till of the Sandy River area and overlies an older till. An excellent natural exposure of these sediments and a recent bulldozed exposure of the buried soil offer one of the finest exposures of Pleistocene sediments to be found in New England. It is not expected that any agreement will be reached concerning the interpretation of these sediments, but it is hoped that a discussion of the sediments may result in the airing of several possible interpretations.

In the road log which follows, some of the interesting and significant features to be seen at each of the field trip stops will be discussed briefly and a few features or exposures at which stops will not be made are mentioned. The Farmington and Norridgewock quadrangle maps, U. S. Geological Survey, show all of the area under consideration and many of the localities to be visited are described in detail in a report published by the Maine Geological Survey dealing with the clay deposits of the Sandy River (Caldwell, 1959). Other literature which deals in part with the Sandy River valley may be found in Stone (1899), Leavitt and Perkins (1935), Trefethen (1947) and Goldthwait (1949).

ROAD LOG

The trip will start at the new dormitory of the Farmington State Teachers College on the south side of Main Street. The mileage shown in the following log is measured from the dormitory. A map of the location of the field trip stops is shown in Figure 1.

Trip C Road Log

Miles from Farmington, Maine.

0.0 Start at Farmington State Teachers College men's dormitory on south side of Main Street. Follow Route 4 and U. S. 2 across Sandy River to West Farmington

1.0 Park on right side of U. S. 2 after crossing Temple Stream. Walk 0.3 miles to clay pit of West Farmington Brick Company.

Stop #1. The clay pit which provides the material used at the West Farmington brick yard affords a good exposure of the lake clay deposited in that area. Approximately 30 feet of clay is exposed in the pit and at least 20 feet more underlies the exposed clay. 1 to 3 feet of fine sand overlies the clay. The upper 20 feet of clay is brown in color and is thought to have been oxidized from the gray-colored clay. Limonite concretions occur in thin sandy partings in the brown clay.

1.3 Return to cars, make U-turn and proceed toward Farmington on U. S. 2. At 1.3 miles turn left at Information Service and take first left-hand turn to West Farmington Brick Company.

Stop #2. West Farmington Brick Company. There will be a short tour of the brick yard, which specialized in water-struck brick.

2.4 Leave brick yard, taking 1st right turn and then left onto U. S. 2. Road crosses flat terrace surface, 400 feet in elevation, which represents outwash plain covering lake clay deposits.

3.2 Stop #3. Park on right side of U. S. 2. Sand pit on left exposes foreset delta bedding. An interesting loess-like silt is exposed in small pit near sand pit. Lake clay underlies these coarser sediments.

3.6 Preceed eastward on U. S. 2. Irregular topography on hill crest is possible fossil dune topography.

4.2 Beyond motel, meander terraces, cut into both the outwash sediments and lake clays, may be seen.

4.7 Road crosses wide meander terrace with outwash plain surface on left. Esker-like ridge is actually narrow remnant of outwash plain.

6.0 Stop #4. Active sand dune area. The sand is derived from outwash sediments and probably became active as a result of overgrazing. Both deltaic and current bedding are exposed in sand pit.

6.4 Proceed eastward on U. S. 2 turning right on Route 41 at 6.4 miles.

6.7 Cross Sandy River. Staurolite schist outcrop on right is only outcrop in channel for more than 10 miles. Turn left after crossing bridge.

7.6 Prominent meander scars and terrace on left. Road is on the original outwash plain surface.

8.3 Stop #5. Undercut slope on meander bend exposes more than 30 feet of interbedded sand and silt with well-preserved ripple marks and varve banding. Gray lake clay is exposed at river level and is at least 30 feet thick as determined by hand auger. The bedding structures in the sand and silt overlying the clay suggest that the coarser sediments were also deposited in standing water, i.e. the lake in which the underlying clay was deposited.

9.2 Proceed along dirt road to junction with Route 134.

10.0 Excellent view of Sandy River valley on left. Dune area at Stop No. 4 visible slightly north of west. On skyline slightly to right of dune area is Mt. Blue. Saddleback Mountain, Mt. Abraham and Sugarloaf Mountain from the skyline toward the north.

10.6 Stop #6. Large esker-like ridges on hill slopes. Composed of medium to fine sand (median diameter = 0.30mm, S_o= 1.54) and may be eolian in origin. Discussion of these features will be welcomed.

11.4 Juncture with U. S. 2. Turn left and cross Sandy River. Notice exposure of gray till on bank of the river down-stream (right) from bridge.

11.6 Turn right on Route 134. 15 minute rest stop at this point. Rest rooms are available at service station on U. S. 2 beyond 134 juncture. Grocery stores, etc., in village.

12.0 Till is exposed from road down to the river, an elevation difference of about 100 feet.

12.2 Stop #7. Lunch will be eaten sometime during this stop and it is suggested that eating materials be taken to the river. Bull-dozed exposure of buried soil shows both the overlying and underlying till. Fragments of wood from soil are dated as more than 35,000 years B.P. (Y-689), suggesting a non-glacial interval older than the classic Wisconsin is recorded (Flint, 1956). A preliminary pollen study of the soil shows a high spruce and pine content and a lack of hemlock pollen, implying a climate somewhat cooler than the present. If this interpretation is valid, the soil was formed, not during the Sangamon interval, but during a post-Sangamon, pre-classic-Wisconsin, non-glacial interval. In this respect, the buried soil at New Sharon is similar to certain non-glacial deposits in Canada described by Terasmae (1958, 1960). Till and interbedded varved clay is exposed across the river from the buried soil locality. The lower till exposed on the south bank evidently is the same age as the till which underlies the buried soil on the north bank and the upper till on the south bank may be correlated with the till which overlies the soil on the north bank. An interesting feature of the lower till is the carbonate concretious which occur in this sediment. These concretions may be controlled in the channel and from gravel bars downstream from the bank exposures. It might be pointed out that fine specimens of red jasper also may be found in these gravel bars. Leaving Stop #7, proceed around corner and turn around in field on left. Proceed back along Route 134 to U. S. 2.

13.8 Turn left beyond motel and restaurant on crest of hill.

14.4 Stop #8. Marine clay overlying till and deformed outwash sediments. A major meander cut-off occurred here during the 1936 spring floods (compare river as shown on Farmington quadrangle with that on Norridgewock quadrangle).

15.9 Junction with U. S. 2, turn left on U. S. 2.

24.6 Esker mantled with marine clay crosses highway.

25.4 Turn left at Twin Pines Motel.

25.6 Turn right into gravel pit.

25.8 Stop #9. Gravel pit in esker. Faulted bedding structures in esker sediments. Esker partly mantled by marine clay. Clay contains well preserved marine pelecypod and gastropod fossils. Similar shells from clay near Clinton, Maine, about 15 miles from Norridgewock, are dated as 11,800 ± 200 years old (W-737).

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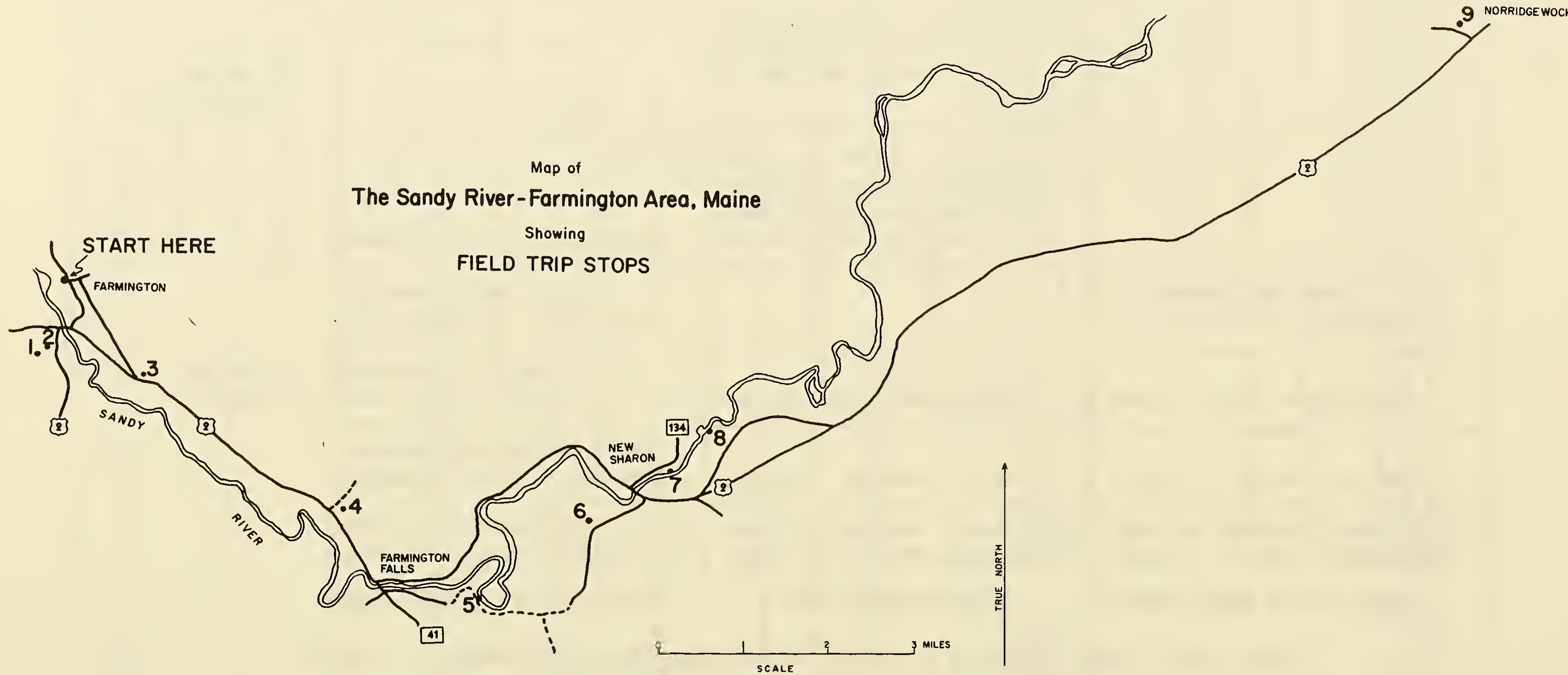
Summary.

The sequence of events and tentative correlation implied by the Pleistocene sediments in the Sandy River valley are presented in Table 1.

Table 1. Summary of late-Pleistocene events in the Sandy River area, Maine

	Upper Sandy River Valley	New Sharon Gorge	Lower Sandy River Valley
	Channel cutting establishment of present flood plain	Channel cutting establishment of present flood plain	Channel cutting establishment of present flood plain
	Draining of glacial lake through New Sharon gorge	Uplift: Retreat of sea	Uplift: Retreat of sea
11,800? years B.P.	Lake clay deposited-covered by outwash	Marine clay deposition	Marine clay deposition
	Deglaciation: formation of stratified drift		Deglaciation: formation of stratified drift
	Deposition of upper till	Deposition of upper till: interbedded varved clay suggests minor oscillations of margin of glacier	
> 35,000 years B.P.		Formation of soil	
		Deposition of lower till	

FIGURE I.



Map of
The Sandy River-Farmington Area, Maine
Showing
FIELD TRIP STOPS

TRIP D. GEOLOGY OF THE OLD SPECK MOUNTAIN QUADRANGLE*

Leader: Daniel J. Milton, U. S. Geological Survey, Cambridge, Mass.

STRATIGRAPHY

The stratigraphic nomenclature developed by M. P. Billings and his co-workers in northern New Hampshire is in general valid in this quadrangle, but is used here only in an informal sense. The sequence, starting with the oldest rock unit, is described below.

Albee formation: Mainly quartzite, commonly showing "pinstriping", thin micaceous partings a few millimeters apart. There is some schist. Because only the upper part of the formation is exposed in this quadrangle, many outcrops are transitional to the Ammonoosuc volcanics, with highly felspathic and chloritic quartzites. Amphibolite is abundant, representing pre-metamorphic basalt sills and dikes. The Albee formation is considered to be of Ordovician age.

Ammonoosuc volcanics: Biotite schist, chlorite schist, amphibolite, minor feldspathic quartzite and aluminous schist. Most of the formation was originally dacitic or andesitic, tuffaceous sediments. Metavolcanic rocks of basaltic and rhyoltic composition are less abundant. The age is middle Ordovician.

Schist and quartzite unit: Two-mica schist and schistose quartzite, usually with garnet and staurolite. Commonly sulfidic and occasionally graphitic. Pinstriping is absent. In stratigraphic position and in lithology this unit corresponds to the Ordovician Partridge formation of western New Hampshire. However, because of complex intertonguing of this and the preceding lithologic types in northern New Hampshire and northwestern Maine, this unit will be given a local name.

A major unconformity (post-Taconic orogeny) separates the preceding units from the Littleton formation. Evidence for the location and even the existence of the unconformity is less clear within the Old Speck Mountain quadrangle than in many other areas.

Littleton formation: As mapped in this quadrangle, this formation may include units older or younger than those represented in the type area near Littleton, New Hampshire. Seven lithologic facies have been mapped. Because of repetition and interfingering, and a rapid thickening from northwest to southeast, these rocks only approximate distinct stratigraphic units. In tentative order from oldest to youngest the faces are:

Amphibolite: A dark, dense metabasalt, locally with pillow structure. This unit, which lies at the base of the Littleton formation on the northwest, may actually belong in whole or in part to the Ammonoosuc volcanics.

Biotite schist: Characterized by the absence or scarcity of muscovite and sillimanite. This rock corresponds in composition to many greywackes and some tuffaceous sediments.

Gneiss: Schist, dominantly biotitic, with knots, veins, and pods of granite, locally grading into a wispy granite. Restricted to the south side of the syncline, this may be the migmatized equivalent of the biotite schist.

Lime silicate granulite: A thin unit, characteristically thinly bedded, composed of quartz, calcic plagioclase, and such magnesian and calcic minerals as phlogopite, hornblende, and diopside. Originally a sandy or shaley dolomite. This unit may correspond to the Boott member of Billings (1956) of the Littleton formation in New Hampshire.

Quartzite and conglomerate: In part clean coarse-grained quartzite and quartz pebble conglomerate, suggestive of the Clough quartzite of western New Hampshire. Also beds that would be included in the next unit except for the abundant to sparse content of pebbles. In the Mahoosuc Range in the southwest part of the quadrangle this unit may be several thousand feet thick.

Interbedded schist and quarzite: Schist, usually two-mica, and quartzite in approximately equal amounts in beds an inch or a few inches thick. Regularity of interbedding and graded bedding are poorly developed.

Two-Mica schist: Peraluminous schist with muscovite and biotite in roughly equal amounts. Sillimanite, or staurolite in the lower grade area, is usually present. Lime silicate concretions are common.

Three distinct groups of granitic intrusive rocks have beem mapped.

Granodiorite of Unbagog Lake: Hornblende granodiorite and diorite, occupying the low ground around Umbagog Lake in the northwest of the Old Speck Mountain quadrangle and in adjacent quadrangles. This granodiorite is intruded and locally metamorphosed to a hornblende-biotite schist by the ordinary intrusives of the New Hampshire plutonic series. It is probably the earliest phase of this series, but could possibly be considerably older, perhaps even of the Highlandcroft plutonic series of Ordovician age.

Granite gneiss: Foliated granite, quartz monzonite, and granodiorite occurring in large sill-like sheets in the Ammonoosuc volcanics. Perhaps in part recrystallized felsic volcanics. These rocks are correlated with the Oliverian plutonic series of New Hampshire.

Post-metamorphic dikes: Mostly diabase, some lamprophyre, bostonite, and a breccia-filled volcanic neck. Such dikes in New Hampshire are generally assigned to the White Mountain plutonic series of Permian age.

STRUCTURE

The dominant structural features are parallel anticlinal and synclinal axes plunging to the northeast. The anticlinal area, an extension of the Jefferson Dome of the Bronson Hill Anticline of New Hampshire, roughly corresponds with the area of the granite gneiss and the pre-Littleton formations. The synclinal area roughly corresponds with the area of the Littleton formation and the instusives of the New Hampshire plutonic series.

The Alternation of younger and older units parallel to the anticlinal axis, together with the general constancy of plunge, indicates that the anticlinal stucture is superimposed on older folds. The map pattern can be explained if the structure is an anticlinorium of parallel anticlinal and synclinal axes superimposed at about right angles, on an older set of approximately northwest-southeast folds (see diagram). Thus, the Albee formation occupies an inverted anticline and the schist and quartzite unit, an inverted syncline with the noses of the areas of outcrop indicating the locations of the later fold axes. The first set of folds probably formed as flowage folds with axial planes dipping away from the Jefferson Dome. The rather tight second stage folding may in part reflect constriction of the Bronson Hill anticline between the plutons on either side. The southeast part of this structure is complicated by the unconformity and perhaps by tectonic flowage.

The syncline in the Littleton formation is an open structure with a steep northwest limb and a gently dipping south limb. The center is largely occupied by semi-concordant plutons, whose outlines suggest the fold pattern. Inconclusive evidence suggests that the syncline, like the anticline, may have an intricate internal structure. Northwest-southeast folds of tens of yards amplitude may be seen on the south limb.

Faulting appears to be of minor importance, although it is indicated by silicified breccia along some contacts.

METAMORPHISM

Most of the quadrangle lies in the lower sillimanite zone of metamorphism. The orthoclase isograd, where potash feldspar and sillimanite occur in place of muscovite, is barely reached in the Mahoosuc Range. Lower grade rocks (staurolite zone) occur in a small area in the southeast (Puzzle and Plumbago Mountains) and in a larger area in the west central part of the quadrangle (including stops 1 through 5). Kyanite and rarely andalusite occur in this area. The Umbagog pluton has a sillimanite grade aureole; the other plutons are at grade with the regional sillimanite zone. Retrograde metamorphism is minor, and mainly evidenced by chloritization of biotite.

TRIP D ROAD LOG

Mileage

0.0 Assemble in parking lot of Sampson's Red and White Market, one block north and west of the Hotel Harris. Cross bridge, turn right and then left following route 2.

0.6 Continue straight ahead and follow route 120 to Andover.

8.8 View ahead of the nearly circular topographic basis around Andover, underlain by a granite-granodiorite pluton. Petrographically it is similar to granitic rocks underlying some of the higher mountains to the west. The latter, intrusions are smaller and contain many screens and pendants of metamorphic rocks, that may account for the increased erosional resistance.

11.3 Left, following route 120.

14.6 Right, following route 120.

15.4 Andover. Enter the Old Speck Mountain quadrangle. Continue straight ahead at stop sign.

17.8 Two-mica schist and interbedded schist and quartzite all of the Littleton formation (sillimanite grade), and quanodiorite of the New Hampshire plutonic series may be seen along the road and in the West Branch of the Ellis River for the next three miles. As therusty yellow weathering indicates, the schists of the Littleton formation are sometimes slightly sulfidic.

23.4 Right, in ditch. Dense, dark, partly bedded amphibolite, intruded by granite. This amphibolite is regarded as the basal member of the Littleton formation in this quadrangle.

23.5 STOP 1. Rocks typical of those near the gradational Albee-Ammonoosuc contact. The white quartzite with fine laminations (pinstriping) is a characteristic Albee formation type, although more feldspathic here than is usual. The more chloritic and biotitic varieties grade into rocks indistinguishable from the Ammonoosuc volcanics and metamorphosed tuffaceous sediments. The foliated, but only weakly layered, amphibolite beds were probably premetamorphic basalt sills. The light green or white mineral in the veins is prehnite. This stop is near the sillimanite isograd.

25.1 STOP 2. Schistose quartzite of the Albee formation (staurolite grade), cut by an amphibolite dike. Note that the dominant foliation, ENE-W SW, parallel to the later structural axes, is a shear cleavage. The highly contorted pinstriping, which presumably indicates bedding, trends NNW-SSE and dips to the NE.

25.2 STOP 3. Foliated granite of a small sill lying near the Albee-Ammonoosuc contact. Like some other small granite bodies lying within the Ammonoosuc volcanics, it resembles the Oliverian plutonic series petrographically.

Outcrops farther along the raod are mapped as Ammonoosuc volcanic on the basis of the dominance of biotite and chlorite schist over quarzite. The essentially volcanic nature of the assemblage is confirmed by the occasional presence of distinctly bedded amphibolite (metamorphosed basaltic tuff). The outcrops are in the staurolite zone of metamorphism.

29.2 Route 26 in Upton. Turn left and then right on gravel road (Back Street). Outcrops in the field at the intersection are Ammonoosuc volcanics, metamorphosed to gneiss and amphibolite in the metamorphic aureole of the Umbagog pluton.

29.5 Purplish, somewhat sulfidic, schistose quarzite of the schist and quartzite unit.

29.8 Massive, rusty weathering, sugary white quartzo-feldspathic rock. Probably metarhyolite of the Ammonoosuc volcanics.

31.1 STOP 4. Pull over to the right to allow cars to pass after turning around. View to the south of the Mahoosuc Range from Old Speck Mountain on the left to Gooseye Mountain on the right, underlain by Littleton formation and intrusives of the New Hampshire plutonic series. The low country and the hills to the west are underlain by Ammonoosuck volcanic and granite gneiss of the Oliverian plutonic series. We walk along a thin schist member within the Ammonoosuc volcanics. The schist is peraluminous, as indicated by the presence of kyanite, and less abundant andalusite and staurolite, but unlike ordinary pelitic schists, it has very little, usually only traces, of muscovite, indicating a low content of K_2O. The M_gO/FeO ratio is unusually high, as indicated by the composition of the chlorites and biotites and also by the scarcity of garnet and staurolite. The unit is well bedded, with the original clastic texture preserved. Clastic granules of quartz may be seen and larger polymineralic fragments may also be primary clasts. The peculiarities of composition suggest bentonite, which is a montomerillonite rock produced by the alteration of volcanic ash by sea water. This unit is interpreted as a poorly sorted sediment containing a considerable amount of unstable (probably glassy) volcanic ash that was altered to montmorillonite soon after deposition.

Follow tracks behind barn up through fields. Behind barn is staurolite garnet schist, one of the most iron-rich varieties.

In the woods by the end of the steep bank near the top of the field is quartz granule-bearing kyanite schist. In the highest corner of the field is a sericitic, but otherwise very pure quartzite. Its genetic relation to this is obscure. PLEASE DO NOT EXTRACT QUARTZ CRYSTALS.

Follow track just below corner of field into woods for about 500 yards. At the crest of the hill is white quartzite on strike with that in the field. About 125 yards beyond is biotite-chlorite-kyanite schist with quartz granules. About 50 yards in the direction of the dip is similar rock with a coarse primary (?) fragmental texture. Just beyond is amphibolite, presumably of original affinities, but exceptionally silica-rich. Return to cars. In the lower fields are several varieties of Ammonoosuc volcanics, mostly metamorphosed felsic tuffs.

32.9 Turn right on route 26.

34.2 Schist and quartzite unit in several roadside outcrops. The rusty weathering is characteristic.

35.3 STOP 5. (May be omitted in case of high water) Go through fields to the Swift Cambridge River. Ammonoosuc volcanics, staurolite grade. The predominant type here is a finely laminated quartzo-feldspathic metasediment, at least in part tuffaceous. There is also dense dark amphibolite (metabasalt). First examine the outcrop about 25 yards across the river at the head of the rapids. Here the metasediment is complexly and isoclinally folded. Note that the finest laminations are occasionally inclined to the fold limbs and may be secondary features. The amphilbolite shows sharp but somewhat crenulated contacts cutting across the folds of the metasediments. Hornblende needles are elongate parallel to the local plunge, but the amphibolites show little internal structure otherwise. The amphibolite may represent original dikes, sills, or even flows. Returning to the river we see the same cross-cutting relationship for the thicker amphibolite bodies. The thinner bodies are concordant, however (note particularly the downstream outcrops on the far side). In general, the divergence from the attitude of the metasediments seems to increase with the thickness of the amphibolite. This suggest that the amphibolite bodies were all orginally concordant, and that the present discordant relationships are the result of the greatly differing competencies of the rock types during deformation. The overall structure seems to consist of open folds of some tens of yards amplitude plunging to the northeast. An amphibolite bed with a crenulated margin on the near bank of the river marks the nose of an apparent syncline. It is believed that this folding is superimposed on an earlier stage deformation that produced the isoclinal fold. Return to cars. Just west of the highway is typical rusty weathering schist and quartzite unit.

36.8 Grafton Cemetery. All that remains of a community that had a population of over a hundred between 1850 and 1800, when virgin timber was to be cut.

37.4 Felsic Ammonoosuc volcanics, here rather sulfidic.

40.9 Grafton Notch. Old Speck Mountain ahead. Ledges to the right are Littleton formation mostly biotite schist; ledges ahead are granite.

43.5 STOP 6. LUNCH. Screw Auger Falls. This is a typical exposure in an intrusive of New Hampshire plutonic series. The dominant rock type is a biotite quartz monzonite, cut by dikes of pegmatite and aplite and containing occasional xenoliths of Littleton formation. The gorge of the Bear River may have been cut in the Pleistocene epoch, when Grafton Notch was the outlet for an ice-dammed lake to the north.

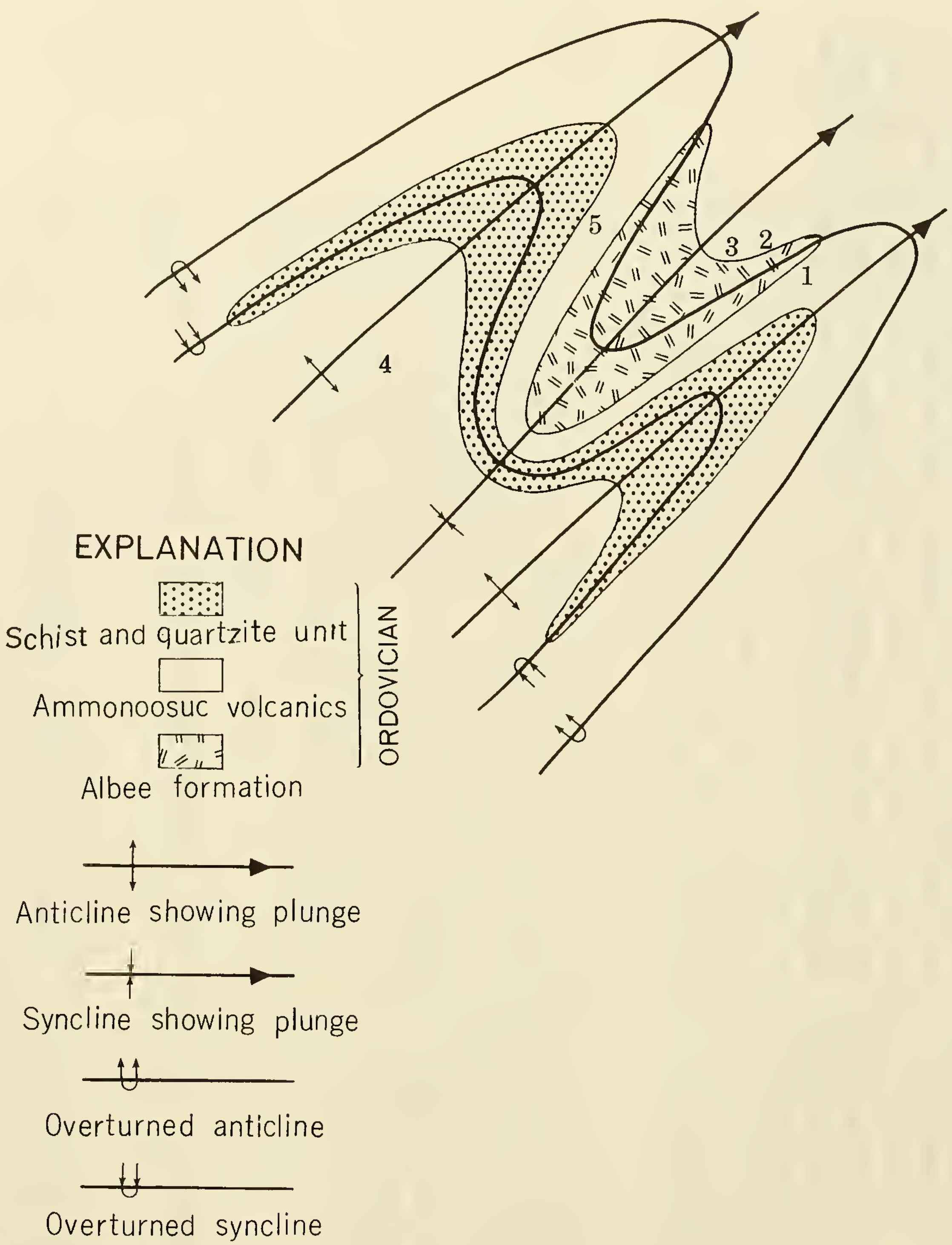
47.2 STOP 7. Littleton formation (sillimanite grade) and pegmatite. The pebble beds determine the outcrop as conglomerate for mapping purposes, but much of the exposure shows the interbedded schist and quartzite lithology. Note the greater deformation of the quartzite pebbles than the vein quartz pebbles. Some lime silicate concretions are present. At the upstream end of the exposure is a well developed example of cleavage banding. Does the grading suggest isoclinal folding in this exposure?

52.4 Newry Corner. Turn right on route 2.

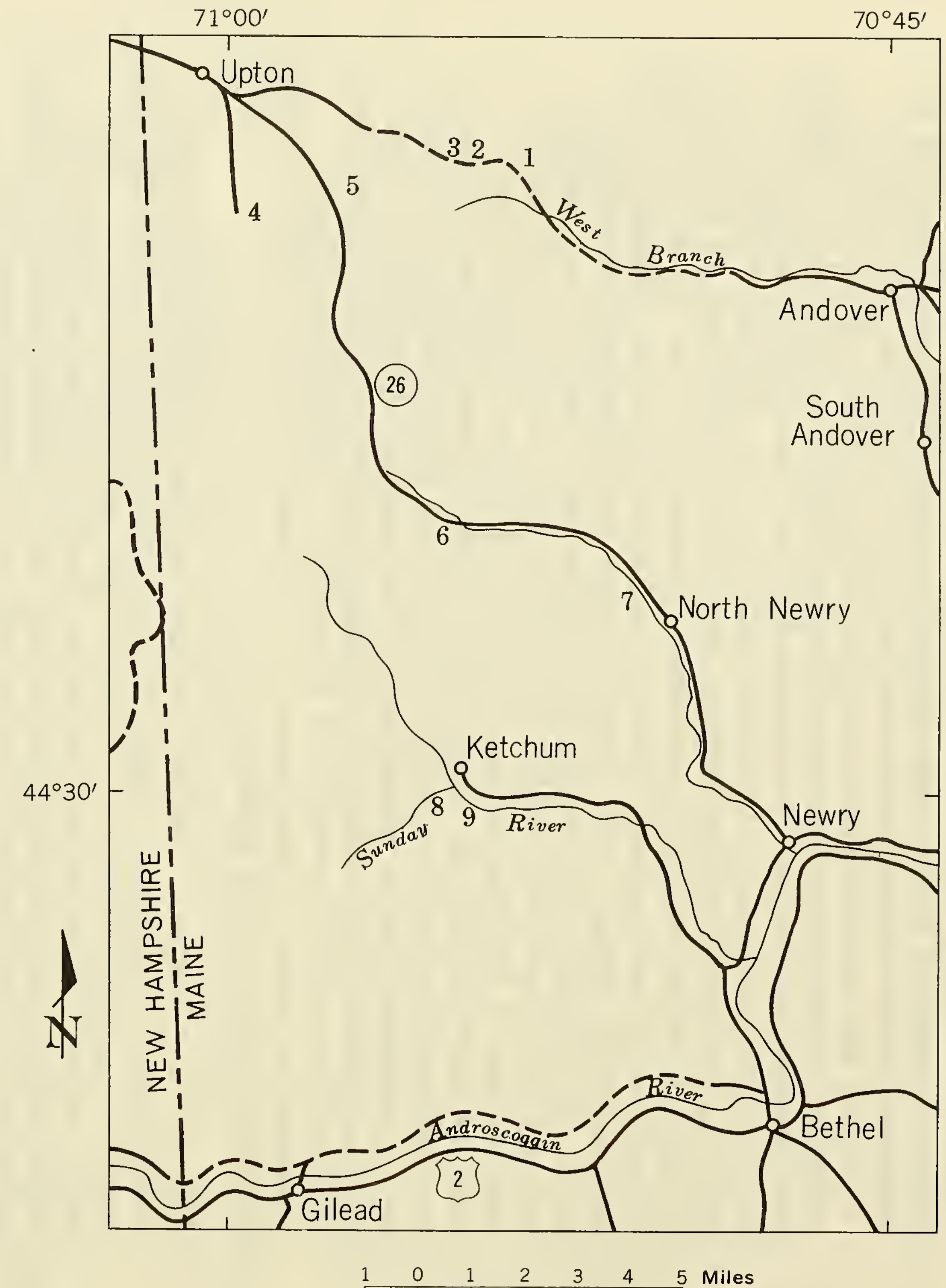
54.9 Turn right on gravel road; right again on paved road up Sunday River.

62.3 STOP 8. Park across bridge. Walk up road to left through gate and down bank to Bull Branch of Sunday River. Littleton formation (sillimanite grade). For several hundred yards upstream the predominant rock is biotite schist (metagreywacke), transitional into gneiss. Note the large lime silicate concretions, usually with a zonation produced during metamorphism. The rolling, low dipping attitudes are characteristic of the whole southern edge of the quadrangle east of the Mahoosuc Range. Above is the thinly bedded lime silicate unit here considered part of the Littleton formation. The fold has a nearly horizontal axis, a very gentle northeast limb and an overturned southwest limb and is the first of a series of similar folds exposed up-stream. These folds may be older than the synclinorium, perhaps related to the early stage folding in the anticlinorial area to the north. Many such folds may be present in the generally steeply dipping Littleton formation, but except in peculiarly fortunate situations like this, where a well-bedded unit crops out on the gently dipping limb of the synclinorium, they would be difficult to recognize. The stream boulders present an excellent collection of the rock types of the Mahoosuc Range. Note especially the porphyritic quartz monzonite (similar to that on Mt. Kinaman), the coarse sillimanite schist, and the occasional sillimanite-orthoclase-biotite granulites, the highest grade metamorphic rocks in this area. Go up bank to road, return to cars and drive back toward highway.

62.3 STOP 9. The ledges. Two-mica schist of the Littleton formation transitional to gneiss. Most of the gneiss member has the granitic component in larger knots, and pods than are present here. The light colored fine-grained two-mica granite occurs especially in small bodies near the margins of more mafic plutons and in intimate association with the metamorphic rocks. The wispy structure parallel to the bedding in the adjacent metamorphic rocks suggests that this granite at least in part formed by transformation of the metamorphic rocks. Left on highway for Rumford, right and follow route 26 to the Maine Turnpike at Gray for the best route to Boston and south.



SCHEMATIC STRUCTURE MAP NEAR UPTON



ROAD MAP FOR TRIP D

Note: Numbers indicate stops

TRIP E MINERALOGY OF PEGMATITES OF THE NEWRY HILL AREA, NEWRY, MAINE

Leader: D. R. Peacor

Meet at 8:15 A.M., Sunday, October 9, at the base of Plumbago Mountain, on Route 5. The meeting place is easily recognized through the Abbott farmhouse on the east side of the road, and the ore hopper and pasture on the west side. The one mile long dirt road up to the mines was passable by car on July 16. If it has been washed out by October we will arrange for jeeps to ferry those few who are unable to walk to the top of the hill.

INTRODUCTION

There are five major quarries in the area (Fig. 1) and many smaller prospect pits. The mineral suites from three of these quarries are different and a unique opportunity to study a wide range of pegmatite minerals is available. These quarries, particularly the Dunton and Nevel quarries, have produced a variety of qualtiy mineral specimens. Persistent mineral collectors have extensively picked over the dumps, but this still remains the finest pegmatite mineral locality in New England.

Mining History

The Dunton pegmatite was first quarried in 1903 and 1904 when it was worked for gem tourmaline, but little gem quality material was found, since the tourmaline was embedded in cleavelandite and had to be blasted loose. (2). The General Electric Company quarried the Dunton, Crooker and Kinglet pegmatites for pollucite from 1926 to 1929 (6), and the dumps of the Dunton Quarry were reworked in 1935 for amblygonite, spodumene and plagioclase. (5). The Nevel Quarry was opened in 1940 and was worked sporadically for feldspar and accessory minerals until 1949 Harvard University and the Whitehall Company unsuccessfully attempted to work the Dunton Quarry for feldspar and gem tourmaline (6). In the mid-fifties the Nevel Quarry was again mined for spodumene and feldspar while the Scotty Mine was prospected and quarried for beryl. None of the quarries is in operation at the present time.

The quarries will be visited in the following order: Nevel; Dunton; Crooker; Scotty; Kinglet. The Crooker and Kinglet Quarries may be by-passed if time is short, since the mineralogy of each is very similar to that of the Dunton Quarry.

General Mineralogy

The Dunton, Crooker and Kinglet pegmatites are similar in that they contain relatively large amounts of albite, especially the variety cleavelandite is associated with the typical accessories such as amblygonite and lepidolite. The Nevel pegmatite contains perthite as the chief feldspar and cleavelandite is less abundant than in the above three pegmatites. The most recent quarrying was carried out in a quartz-cleavelandite-spodumene zone, the debris of which covers up old dump material, thus giving the appearance that this zone is unduly important. Lepidolite is rare in the Nevel Quarry, and lithia tourmaline has not been found. The mineral suite of the Scotty pegmatite is entirely different than those of the other pegmatites. Cleavelandite is not present, and perthite is the major feldspar, although some albite is found. The lithia minerals characteristic of the other pegmatites are lacking, but this pegmatite is the only commercial beryl prospect in the area, the other pegmatites being worked for feldspar and accessory pollucite, amblygonite, spodumene and gem tourmaline.

Nevel Quarry

This quarry, the largest of the group, is unfortunately filled with water, and only a short entranceway is accessible. The dumps are extensive and relatively fresh however. Dump material from the mining operations of the mid-forties has been used as road fill. This is actually one of the better exposures of rock removed at this time as more recent dumpings cover waste near the mine.

Shainen recognizes four intermediate zones in addition to the border, wall, core and core margin zones. (6). The relatively fine-grained wall zone entirely surrounds the quarry. Tourmaline (variety schorlite) occurs sparsely only in this zone with minor garnet, and in the thin border zone. Actinolite-chlorite schist originated through pegmatite and granite contact metamorphism of gabbro (6) and is exposed above the quarry. Some segregated actinolite may be seen in the border zone, and schorlite crystals are abundant in the schist, particularly near the contact.

The quartz-albite-perthite-triphylite pegmatite (intermediate zone) is exposed on the right side of the quarry entranceway. The triphlite is partially altered to heterosite (purple when fresh or powdered) and blue vivianite. Fragments of this zone are abundant in the road fill leading to the quarry.

The most recent dump material is easily recognized by the fresh white appearance. Spodumene crystals six to eight inches in diameter and three or four feet long are not unusual, and are usually embedded in a quartz-cleavelandite matrix. White anhedral beryl partially replaced by cleavelandite, red-black sphalerite and blue-green manganapatite occur in masses up to six or eight inches in diameter associated with the spodumene. A tapialite crystal over an inch in diameter was found embedded in sphalerite associated with spodumene, muscovite and quartz. Small columbite and cassiterite grains embedded in quartz are abundant. Lepidolite occurs sparingly as small plates in massive quartz, and aggregates of amber prisms of eosphorite three or four mm. long line cavities in cleavelandite.

Some fragments from the triphylite zone exposed in the entranceway are scattered over central part of the dump. Triphylite is abundant, occasionally as unusual euhedral crystals embedded in quartz. Shainen estimates that this zone contains 43% quartz, 22% triphylite, 18% albite, 15% muscovite, 2.02% beryl, and minor black tourmaline and columbite. Fairfieldite (white sheafs of crystals four or five mm. long in cavities after triphylite, with prismatic blue vivianite crystals), heterosite and vivianite are alterations of the triphylite. Some manganapatite is also present. The fairfieldite and vivianite crystals are hydrothermal triphylite alterations while the heterosite and earthy vivianite are weathering products.

The following minerals were found during quarrying from 1940 to 1949 but were not observed recently on the dumps.

Rose quartz crystals: Up to three quarters inch long in clusters lining cavities in the core margin zone (6).

Uraninite: Small euhedral to subhedral crystals in the core margin and some intermediate zones (6).

Amblygonite: Some of the finest crystals known were found lining cavities in the core margin zone associated with quartz, beryl, triphylite, eosphorite, cassiterite and rhodochrosite (4).

Rhodochrosite: In cavities with amblygonite (4).

Autunite: Yellow-green films of platy crystals near altered uraninite or along open joints.

A small water-filled pit south of the Nevel Quarry is in perthite-quartz--albite pegmatite. The associated dumps contain siderite after deeply altered triphylite, columbite, and spodumene as accessories.

Dunton Quarry

During recent mining and reworking of the dumps, the quarry was almost entirely filled in with old dump material, and now little may be seen of the structure of the pegmatite. A fairly large section of the upper quarry wall is still exposed however. Minor black tourmaline and garnet occur in the border zone (one to three inches thick, 99% albite) and wall zone (eight inches to four feet thick, 60% quartz, 30% albite, 6% muscovite.) Shainen recognized two intermediate zones in addition to the core and core-margin zones (6). Cleavelandite is the major feldspar of all of these zones, and lithia tourmaline in some color variety is found in all zones. Some of the intermediate zone is exposed in the upper quarry wall.

Lilac aggregates of lepidolite plates intergrown with cleavelandite, quartz, spodumene, and green, red and blue tourmaline are common on the dumps. Green tourmaline is commonly enclosed in muscovite books, while watermelon tourmaline crystals up to three inches in diameter are embedded in large perthite crystals. Massive blue tourmaline is intimately associated with triphylite which is often altered to siderite, vivianite and heterosite. The triphylite may be completely altered, leaving a cavity in blue tourmaline, and black manganese oxides may coat all of these minerals.

Herderite occurs as small "gumdrop"-like spheroidal groups in cavities in cleavelandite. Prismatic eosphorite crystals similar to those found in the Nevel Quarry, are also found lining albite cavities.

The following minerals have been found in past years but were not found on recent field trips.

Beryllonite: Palache and Shannon described this mineral as occurring in white crystals embedded in cleavelandite. It alters to fibrous botryoidal herderite, and is often coated with that mineral (1).

Amblygonite: Cameron recorded a mass of pegmatite 25 feet by 15 feet made up predominantly of amblygonite nodules six to eight inches in diameter (5). Amblygonite is usually associated with cleavelandite and lepidolite.

Pollucite: Large masses were associated with lepidolite, spodumene and pink tourmaline, and fractures in it were filled with chalcedony (2).

Microlite: Octahdral brown crystals are embedded in lepidolite or cleavelandite (6).

Cassiterite: Subhedral small crystals are embedded in cleavelandite (6).

Francolite: "Light colored radiating masses" coating crystal cavities (2).

Fraser has reported opal, pyrite, apatite, sphalerite, reddingite and rose quartz crystals (2). Shainen recorded autunite and torbernite (6) while Hess and others have reported "gummite" and uranophane as alterations of uraninite (3). Beryl is only a minor accessory mineral.

Scotty Quarry

This quarry is water free and the pegmatite structure is well exposed. Perthite is the dominant feldspar, but some non-cleavelandite albite is present. Very little of the beryl for which this mine was worked can now be found. Occasional crystals one or two inches in diameter occur in the quarry wall. Large crystals over a foot in diameter were once quarried.

The following minerals were recently observed.

Tourmaline: Layers of aggregates of small black crystals at the contact and in the contact rocks.

Garnet: Crystals up to a quarter inch in diameter are common in the wall zone. The color of some suggests that they are spessartite.

Triphylite: Found sparingly and usually altered to siderite, heterosite or vivianite.

Ludlamite: Aggregates up to an inch in diameter were found with siderrite as a hydrothermal triphylite alteration.

Columbite: Tabular crystals up to three inches long.

Anthophyllite: A single one one half inch seam was found in the contact rock.

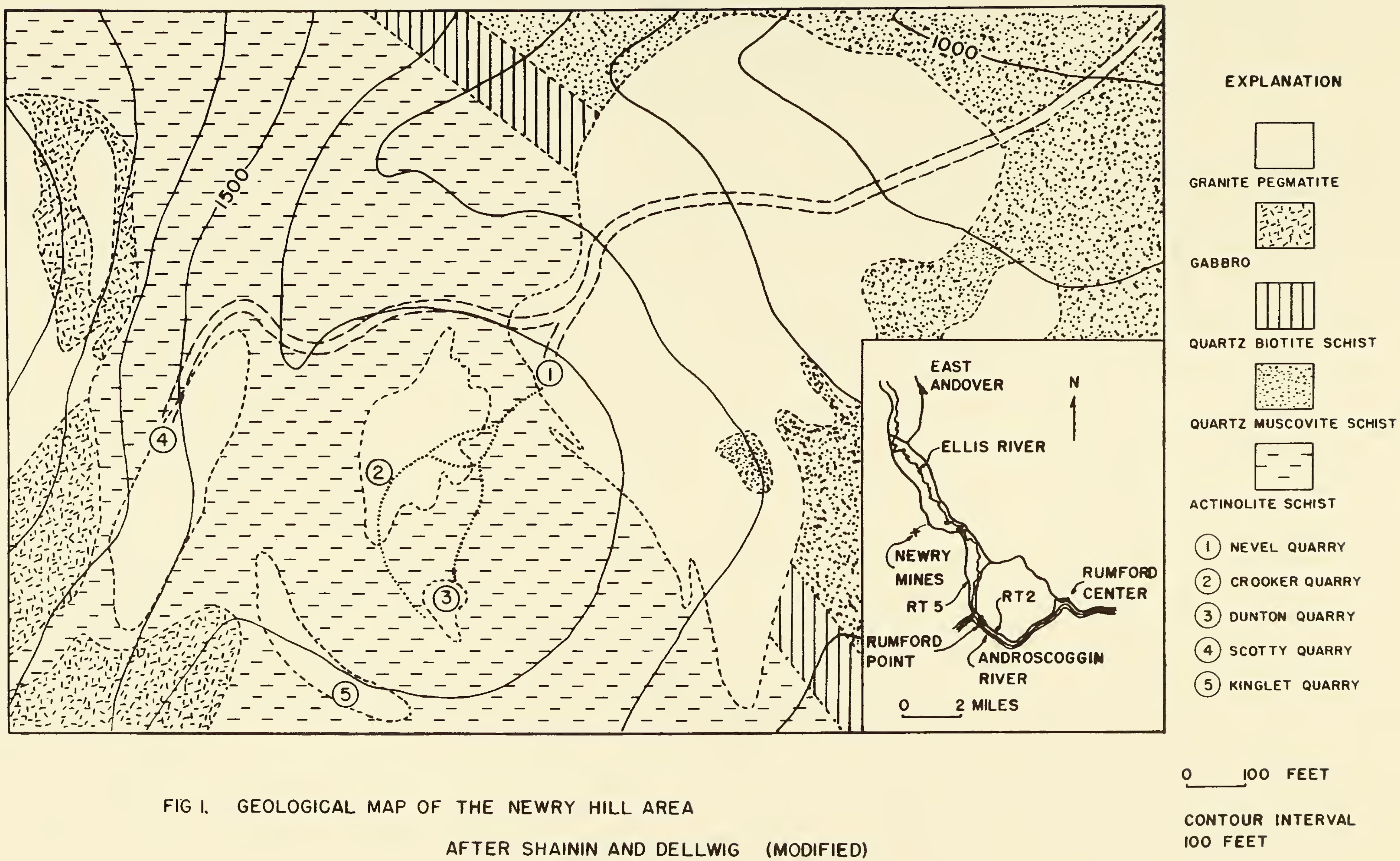


FIG I. GEOLOGICAL MAP OF THE NEWRY HILL AREA

AFTER SHAININ AND DELLWIG (MODIFIED)